State of Wisconsin/Department of Transportation
RESEARCH PROGRESS REPORT FOR THE QUARTER ENDING: September 30, 2004

Program: SPR-0010(36) FFY99	**Part: II Research and Development**
Project Title: Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements Prior to an Asphaltic Concrete Overlay	**Project ID:** 0092-04-05
Administrative Contact: Nina McLawhorn	**Sponsor:** WHRP
WisDOT Technical Contact: Len Makowski	**Approved Starting Date:** Oct 1, 2003
Approved by COR/Steering Committee: $64,966.00	**Approved Ending Date:** Apr 1, 2005
Project Investigator (agency & contact): Haifang Wen	

Description:

Total study budget	Current FFY budget	Expenditures for current quarter	Total Expenditures to date	Percent Complete
$64,966.00	**$32,483.00**	**$18,774.70**	**$48,968.22**	**59.2%**

Progress This Quarter:
(Includes project committee mtgs, work plan status, contract status, significant progress, etc.)

Field study was performed on STH 33, Washington County, WI, in terms of distresses survey and FWD testing. Data analysis is under way.

Based on the data collected from previous overlay projects, preliminary analysis was conducted. The following is the findings at this time. In-depth study, including effect of surface preparation, is under way.

DATA ANALYSIS
The data collected through the above procedures were analyzed statistically. The correlation among the variables was investigated to find the factors influencing the performance of asphalt overlay in term of rutting and roughness. Table 1 shows the selected projects.

TABLE 1. List of Projects of Asphalt Overlay of Existing Asphalt Pavements in Wisconsin

Project ID	Road	# of Sections	Overlay Year	HMA Mix Type
5964-00-60	STH 133	13	1994	LV
5967-02-60	STH 126	5	1993	MV
5070-00-61	STH 154	8	1994	MV
5090-02-72	STH 33	5	1995	MV
6020-01-62	US 51	9	1994	HV
5155-00-60	US 14	9	1994	MV
1701-05-72	STH 11	4	1995	Warranted
6040-01-72	STH 33	4	1990	Unknown
6030-01-71	STH 22	15	1988	RAP
5596-03-71	STH 81	12	1989	Unknown
3325-01-70	STH 67	4	1994	MV
2302-05-70	STH 167	4	1994	MV
1330-00-70	STH 83	4	1993	MV

Table 2. List of Projects of Asphalt Overlay of Existing Concrete Pavements in Wisconsin

Project ID	Road	# of Sections	Overlay Year	HMA Mix Type
1401-03-71	STH 16	3	1992	Special
1067-01-72	IH 94	6	1995	HV
3230-01-70	STH 50	6	1989	Special
1430-00-70	STH 23	6	1994	HV
2025-02-76	STH 190	1	1989	Special
1430-00-71	STH 23	6	1996	HV
2240-08-70	STH 36	1	1996	HV
2030-03-71	US 45	2	1993	HV
1092-05-72	I-43	16	1993	HV
1080-00-70	US 12	19	1993	HV

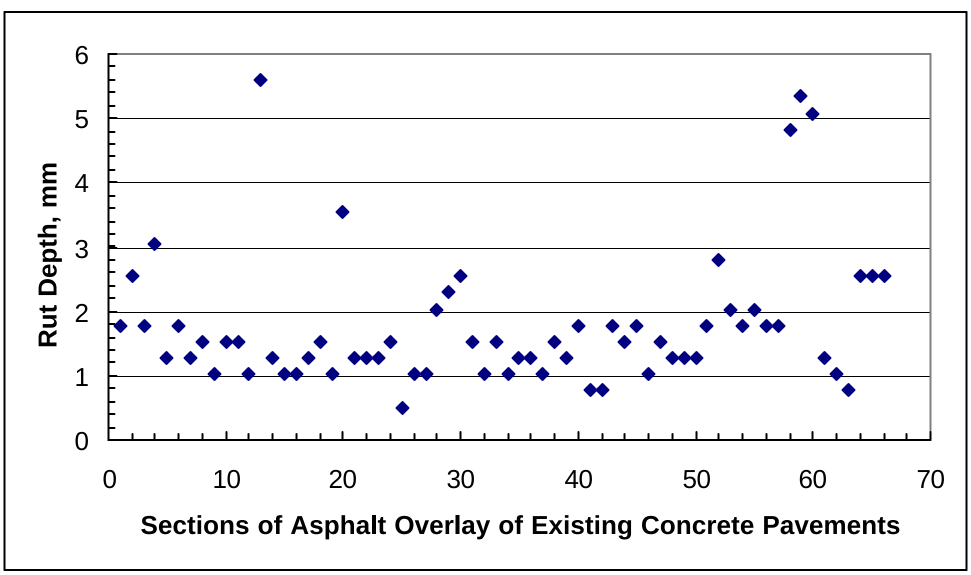
Asphalt Overlay of Existing Concrete Pavement

Rutting in Asphalt Overlay of Existing Concrete Pavement

For the sections selected, most of the existing concrete pavements were overlaid with approximate 3.5 inches Hot Mix Asphalt (HMA), with a range of 2.5 ~ 4.5 inches. Prior to the placement of asphalt overlay, it has been a common practice to repair the existing concrete pavements. However, the amount of repair varied, depending on the severity of distresses and availability of funding.

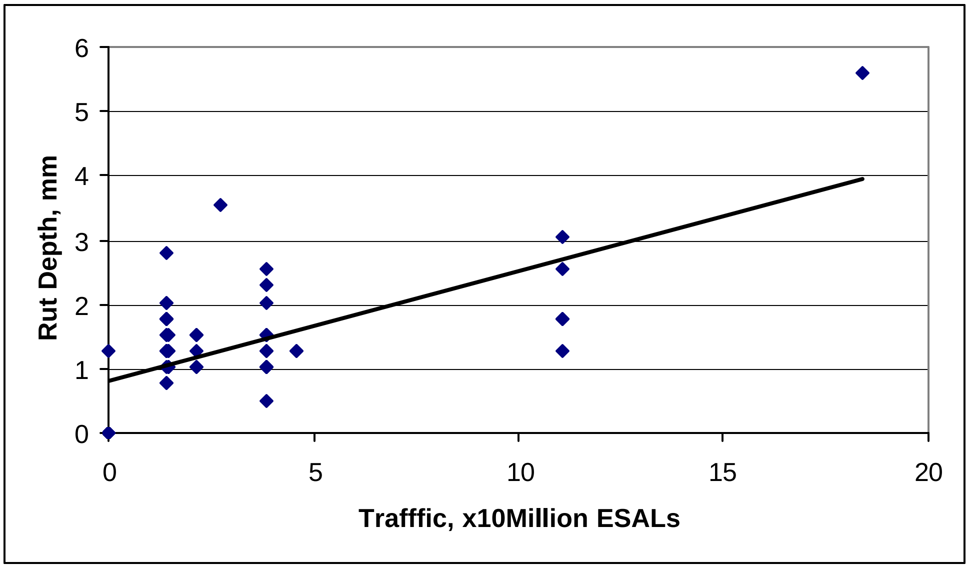
Figure 1 shows the current rut depths in asphalt overlay of existing concrete pavements in this study. It could be seen that the most of rut depths in asphalt overlay of existing asphalt pavement were less than 0.1”, after a service period of 6 ~ 13 years. This holds true for even for these sections with high traffic volume and a long service period. Therefore, rutting in asphalt overlay of existing concrete pavement was insignificant. This observation agrees well with the finding by Hall *et. al*. The rutting may be from compaction of mix by traffic. It was reported that the rutting in asphalt overlay of concrete pavements occurred and developed within the first two years after the overlay. The minimal rutting in asphalt overlay of concrete pavement indicated that the asphaltic materials used in the overlays were resistant to rutting. Rutting was a result of permanent deformation of HMA subject to repeated traffic. For the pavements in this study, the rut depth increased with an increase of traffic volume, as indicated in Figure 2.

Figure 1. Rut Depth in Asphalt Overlay of Concrete Pavements



Considering the solid base for asphalt overlay of existing concrete pavement, rutting occurred only in asphaltic layer. If rut depth was significantly larger than 0.1”m and occurred within initial service years, it could be concluded that rutting might be ascribed to the instability of asphaltic mixes.

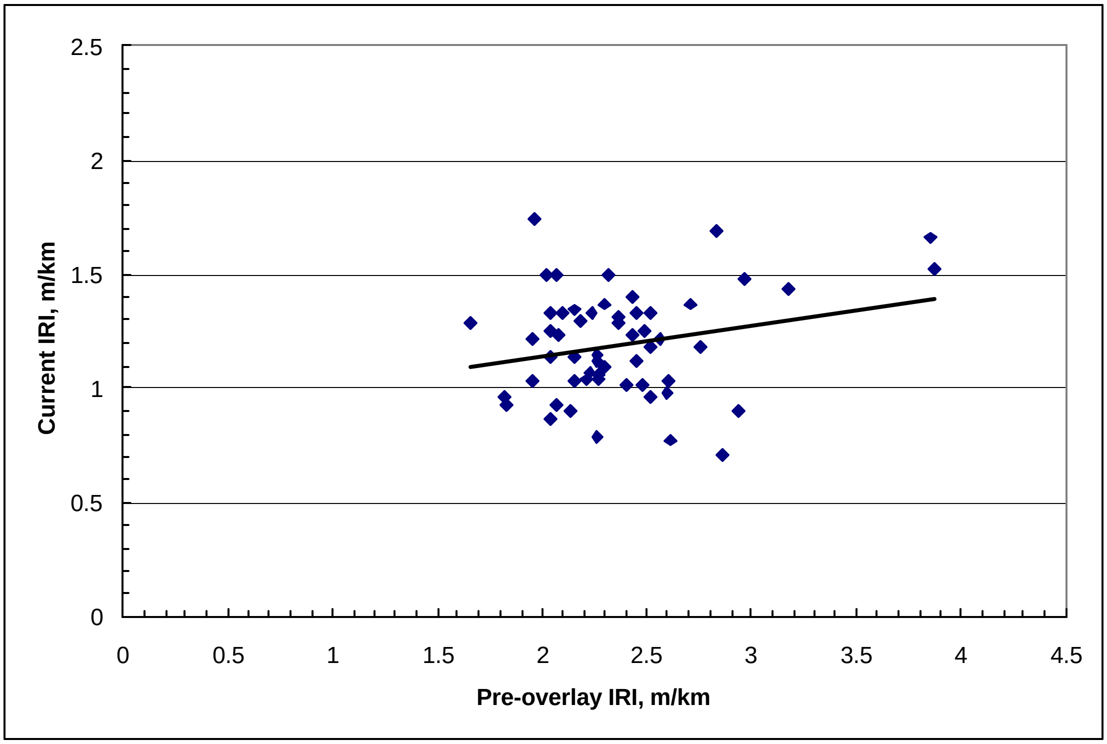
Figure 2. Traffic versus Rut Depth in Asphalt Overlay of Concrete Pavements



Roughness of Asphalt Overlay of Existing Concrete Pavement

Roughness of asphalt overlay could be affected by many factors, such as pre-overlay roughness, pre-overlay repair, and distresses, etc. International Roughness Index (IRI) is a measurement of roughness of pavement, as a functional performance. In this study, the effects of pre-overlay IRI, initial IRI after placement of overlay, and traffic on current roughness were investigated. Figure 3 shows the relationship between pre-overlay IRI and current IRI. It seems that with the increase of pre-overlay IRI, current IRI increased slightly. This correlation between pre-overlay IRI and current IRI was coupled with pre-overlay repair. With the increase of the amount of repair, the effects of pre-overlay IRI on current IRI should decrease. The study of the effects of amount of repair prior to the placement overlay is underway.

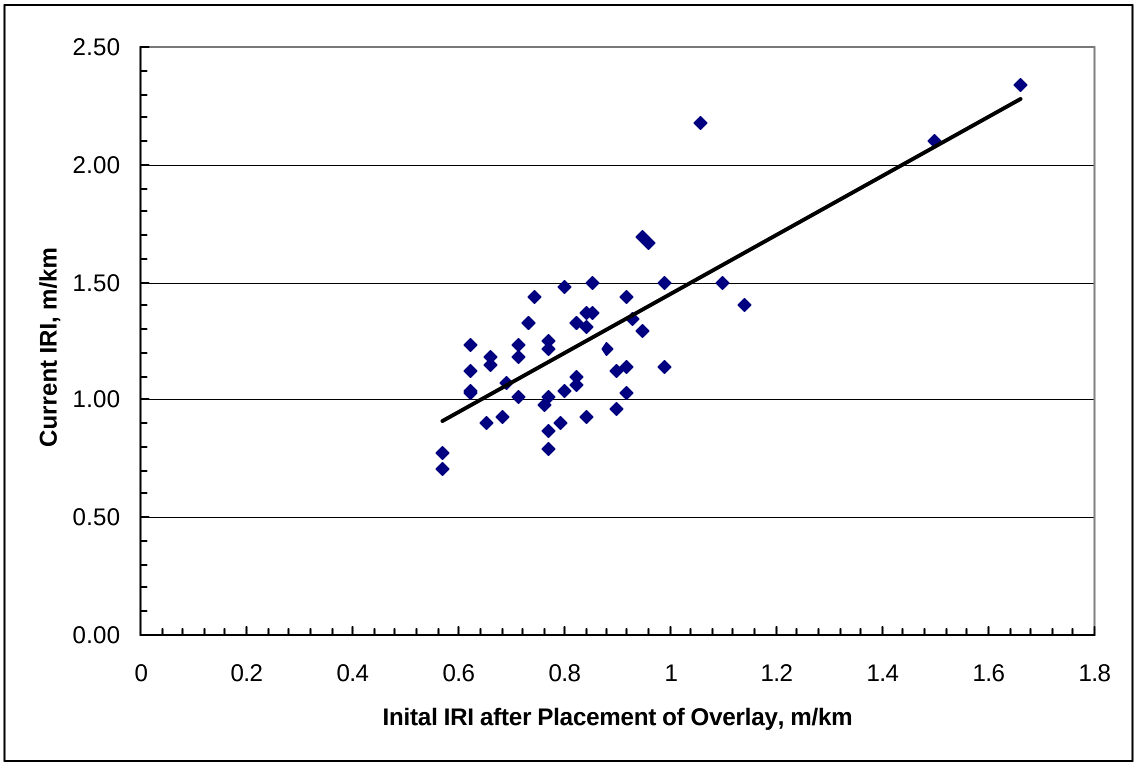
Figure 3. Pre-overlay IRI versus Current IRI in Asphalt Overlay of Concrete Pavements



Initial IRI right after placement of overlay is affected by construction and pre-overlay IRI. The correlation between pre-overlay IRI and initial IRI, however, was not significant. This is probably because modern asphalt paving equipments could correct the roughness of existing concrete pavement. This finding, however, was in contrast to the observation by Hall *et. al*. in which initial IRI after placement of overlay was found to increase with the increase of pre-overlay IRI.

The relationship between initial IRI after the placement of overlay and current IRI was investigated. Figure 4 indicated that initial IRI had a significant correlation with current IRI. With the increase of initial IRI, current IRI increased as well. Therefore, profile index in asphalt overlay of concrete pavement is a critical factor influencing the future performance of asphalt overlay.

Figure 4. Initial IRI versus Current IRI in Asphalt Overlay of Concrete Pavements



In addition, traffic affected the roughness of asphalt overlay. As seen in Figure 5, high traffic volume resulted in large current IRI value. This is probably because higher traffic volume resulted in more severe distresses, such as reflective cracking, which contributed to roughness in overlay.

Asphalt Overlay of Existing Asphalt Pavement

Rutting in Asphalt Overlay of Existing Asphalt Pavement

Compared to rutting in asphalt overlay of existing concrete pavement, rutting in asphalt overlay of asphalt pavement is more severe. This is because in overlaid asphalt pavement, the load by traffic is distributed into base course and subgrade, instead of the solid concrete in overlaid concrete pavement. Therefore, rutting in overlaid asphalt pavement is a sum of permanent deformation in asphalt overlay, existing asphaltic layers, base course, and subgrade.

The relationship between pre-overlay rutting in existing asphalt pavement and current rutting in asphalt overlay, was investigated. As seen in Figure 6, there was a strong correlation between pre-overlay rut depth and current rut depth in asphalt overlay of asphalt pavement, regardless of traffic volume or age of overlay. This finding indicated that severe rutting was very likely to occur again in overlaid asphalt pavement with severe rutting. Therefore, asphalt overlay may not be an effective way to rehabilitate asphalt pavement with severe rutting. Caution should be exercised when asphalt overlay is planned due to excessive rutting. Since no significant rutting occurred in asphalt overly of existing concrete pavement, it seems that the asphalt mixes used in previous WisDOT projects were resistant to rutting. Therefore, underlying base course and subgrade conditions should be investigated. If instable materials exist in base course, pulverization and overlay is preferred. If the severe rutting in existing asphalt pavement is due to poor soil conditions, reconstruction may be warranted, instead of overlay.

Other factors affecting the rutting in asphalt overlay were also studied. However, it was found that overlay thickness, age, and asphalt concrete mix type did not directly affect rut depth in asphalt overlay. This finding does not indicate the above parameters are not factors for rutting but significant correlation were not found based on the data available.

Figure 5. Traffic versus Current IRI in Asphalt Overlay of Concrete Pavements

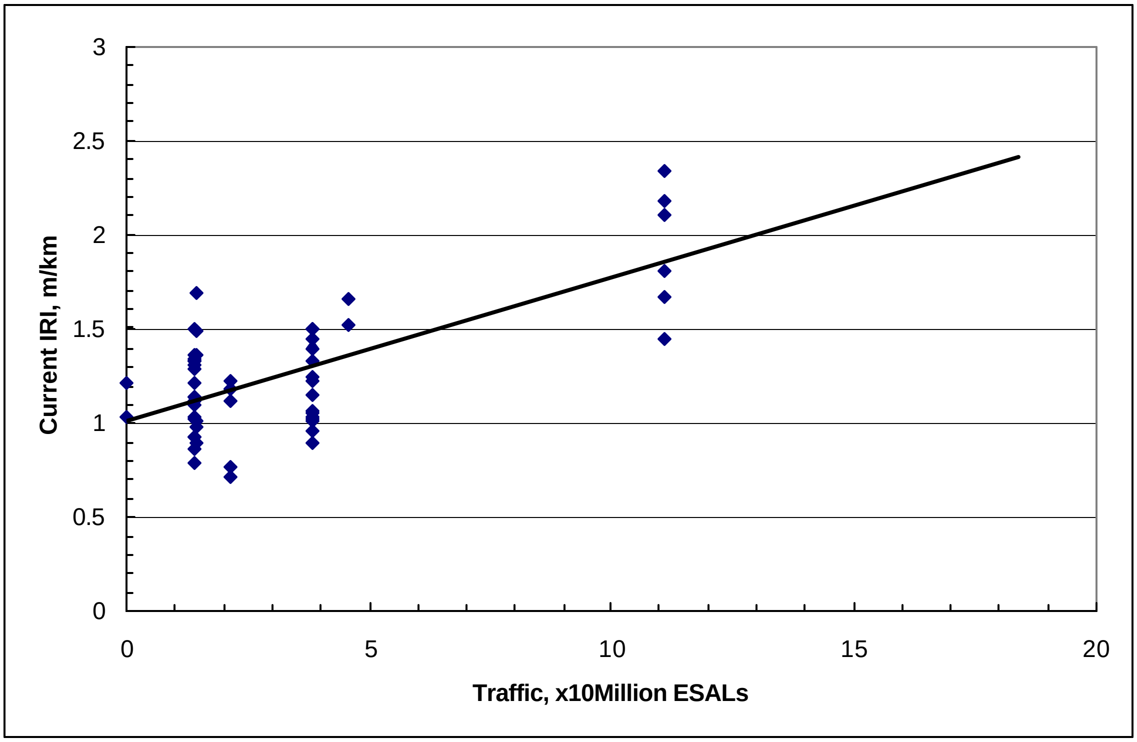
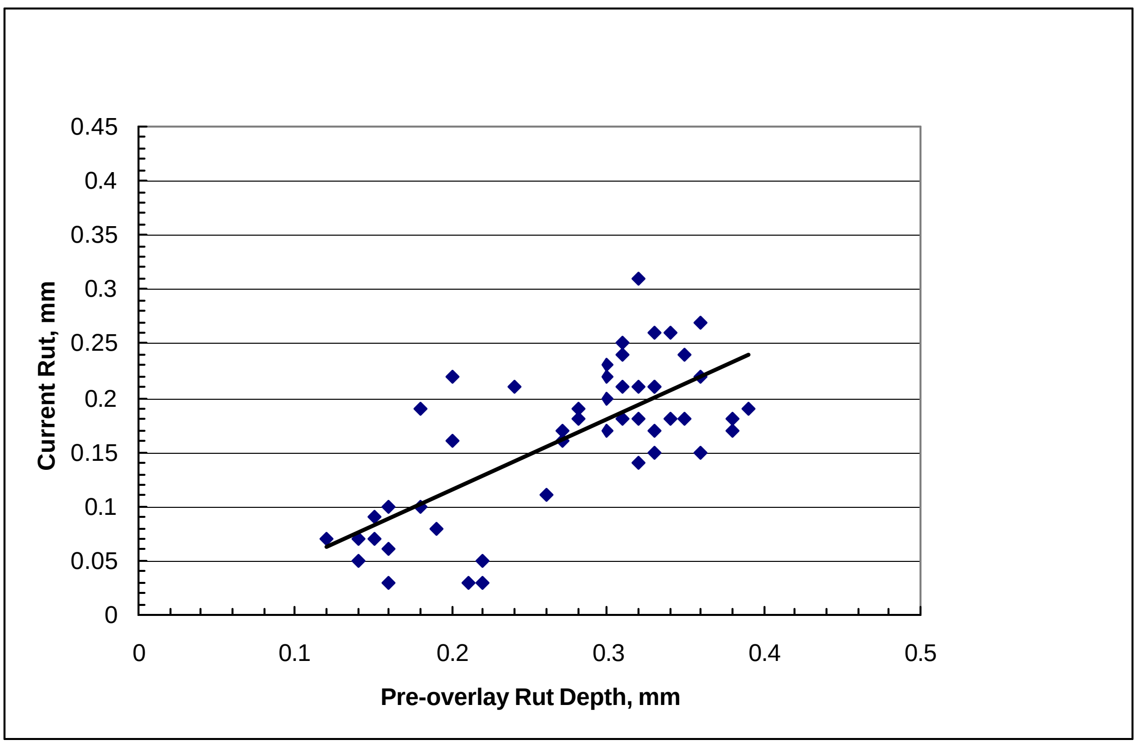


Figure 6. Pre-overlay Rutting versus Current Rutting in Asphalt Overlay of Asphalt Pavements

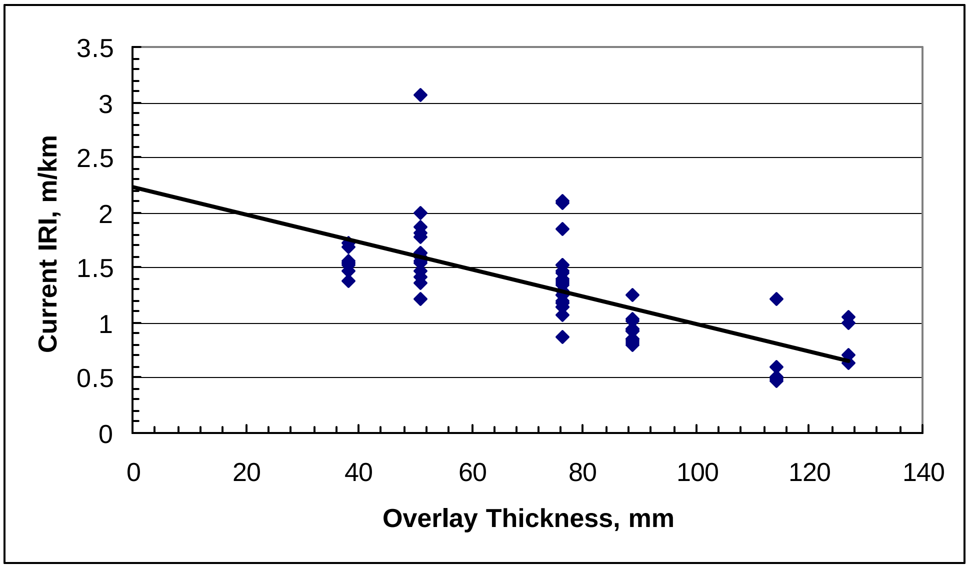


Roughness in Asphalt Overlay of Existing Asphalt Pavement

Roughness of asphalt overlay of existing asphalt pavement may be affected by several factors, such as pre-overlay roughness, repair method, distresses, and traffic volume.

As shown in Figure 7, current IRI values decreased with the increase of overlay thickness. This observation agrees well with the finding by Hall *et. al*. in which the five-inch overlays in the SPS-5 experiment had significantly lower long-term roughness than the two-inch overlays. Data analysis indicated that there was no correlation between current IRI and pre-overlay IRI, traffic volume, or repair method, based on the data available in this study.

Figure 7. Effects of Overlay Thickness on Current IRI in Asphalt Overlay of Asphalt Pavements



LOCAL VALIDATION OF ROUGHNESS PREDICTION MODEL FOR ASPHALT OVERLAY OF CONCRETE PAVEMENT IN 2002 DESIGN GUIDE

In recently released 2002 design guide, one advance is the adoption of distress prediction models to predict the future performance of pavements. These models were developed based on regression of data obtained from LTTP. The distress prediction models in asphalt overlay of existing asphaltic and concrete pavements are provided, including roughness prediction. For roughness in asphalt overlay of rigid pavement, the roughness prediction model is presented as follows:

$$IRI=IRI_0+0.0082627(t)+0.0221832(RD)+1.33041\left(\frac{1}{(TC_S)_{MH}}\right) \qquad (1)$$

Where:

IRI_0 =Initial IRI at the time of HMA overlay placement, m/km,
t =Time after overlay placement years,
$(TC_s)_{MH}$=Average spacing of medium and high severity transverse cracks, m
RD =Average rut depth, mm.

Considering the variation of materials, construction, and climate, it is imperative that the above distress prediction model be validated locally. In Equation (1), initial IRI, service years, and rut depth are available in WisDOT PIF database. However, the transverse cracking survey method used by WisDOT is different from that in LTPP. According to WisDOT *Pavement Surface Distress Manual,* the severity of transverse cracking is categorized as follows:

0 = None,
1 = less than ½" in width,
2 = greater than ½" in width,
3 = band cracking (multiple cracks in close proximity resulting in a narrow band of cracks) with or without dislodgement. A transverse crack is banded if the pavement area affected is within 0.31m of the crack.

The severities of "2" and "3" are considered as "medium" and "high", respectively. During distress survey, sealed and adequately filled cracks was rated as severity level 1 unless one can tell that the cracks are severity level "2" or "3". Crack sealing disguised the appearance of transverse cracks. However, the conditions of transverse crack were not improved and thus, the severity remains same after sealing, or worse under traffic. To objectively evaluate the severity of the transverse cracks, the worst case in the history of distresses was brought forward and used in the data analysis. For instance, if the database indicated that a severity of transverse cracks was "3" in 1998 and "1" in 2002 due to crack sealing. A severity of "3" will be used for 2002.

The extent of transverse cracking was determined from the average number of transverse cracks per 100 feet in the survey segment. A transverse crack should be 6 feet in length to be counted. According to the WisDOT *Pavement Surface Distress Manual*, the extent of transverse cracking was categorized as follows:

0 = None,
1 = 1 to 5 cracks per 100 feet,
2 = 6 to 10 cracks per 100 feet,
3 = greater than 10 cracks per 100 feet.

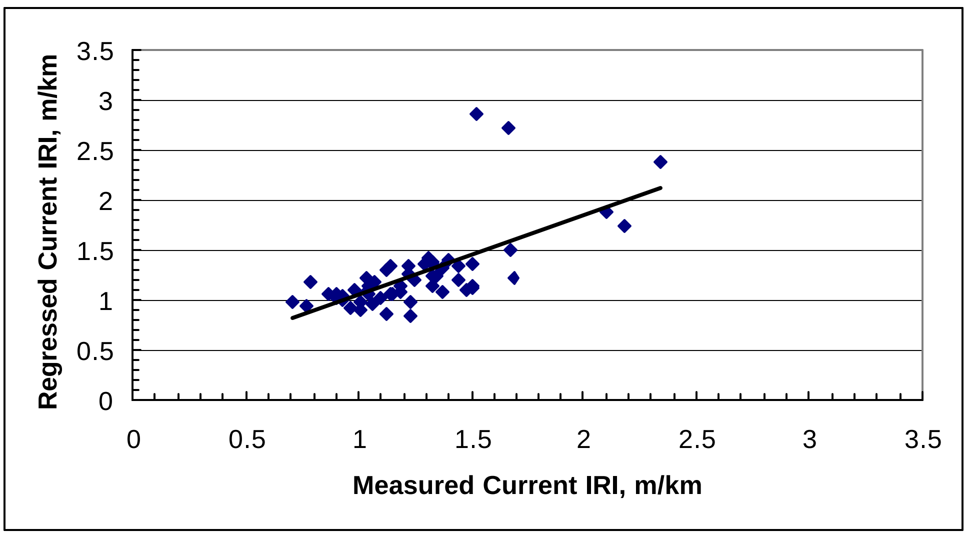
It is noted a range of number of cracks was recorded in the PIF database, instead of exact count. Therefore, the average of number of cracks was used in the analysis. For the extent of “3”, 10 cracks were used which happened only once in the selected sections. Even though using average number of cracks may bring extra errors, the pattern of the extent of cracks was approximately similar to exact count.

A nonlinear regression was performed to obtain the coefficients in Equation (1). The results of regression indicated that the following roughness prediction model should be used in Wisconsin:

$$IRI=IRI_0-0.0113(t)+0.2367(RD)+1.0081\left(\frac{1}{(TC_S)_{MH}}\right) \qquad (2)$$

It is noted that the coefficient for overlay placement years is a negative which is not practically meaningful. The roughness of pavement generally increases with the increase of overlay placement years. However, the absolute value of this negative coefficient was small in both Equations (1) and (2). The effects of overlay placement years on roughness were minimal. The measured and regressed IRIs using Equation (2) were shown in Figure 8.

Figure 8. Measured IRI versus Regressed IRI in Asphalt Overlay of Concrete Pavements



Work Next Quarter:

Analyze the data collected from field study and perform in-depth study of effects and amount of surface preparation on overlay performance.

Circumstances affecting progress/budget:

None

Gantt Chart:

Project I.D.	Starting Date	Completion Date	Quarter	Report
0092-04-05	***Oct. 1, 2003***	***Apr. 01, 2005***	***3rd - 2004***	**4**

CONSULTANT NAME	% Time Elapsed	Total Project Funding	Contract Funding
Bloom Consultants, LLC	**66%**	**100%**	**100%**

Name of Study
Guidelines for the Surface Preparation/Rehabilitation of Existing Concrete and Asphaltic Pavements Prior to an Asphaltic Concrete Overlay

TASK	YEAR: 2003	2004				2005	*PERCENT OF* Project	Task Complete Last Report	Task Complete This Report	Project Complete
MONTH	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1				
Task 1: Review Wisconsin Procedure on Surface Preparation							9.8	100	100	9.8
Task 2: Review National Research on Surface Preparation							9.8	80	100	9.8
Task 3: Identify Projects for Field Comparisons							52.8	50	75	39.6
Task 4: Guideline Development							15.7	0	0	0
Task 5: Prepare and Submit Final Proposal							11.9	0	0	0
Show Progress by Use of Bar Char: **Scheduled** / **Completed**							100			59.2

Note: Gantt chart shown in State Fiscal Year Quarters